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Non-Renewable Resources for the Energiewende – A Social Life Cycle Analysis

Schlör, H.[a], Zapp, P.[a], Marx, J.[a], Schreiber, A.[a], Hake, J.-F.[a]

[a]*Forschungszentrum Jülich, IEK-STE, 52425 Jülich, Germany*

Abstract

The Rio +20 conference in 2012 confirmed not only the sustainability concept as the new development goal but also introduced the green economy as its implementation strategy and the life cycle assessment (LCA) as one of its analysis tools to reveal the current production and consumption patterns which affect human well-being.
Human well-being therefore has to be defined. We describe human well-being using the capability approach of Amartya Sen. Current production and consumption patterns have an influence on human well-being, on people's functioning and capabilities. Consumption patterns alter and the energy sector is in Germany at the centre of that process. Renewable energy technologies are seen as instruments for a transformation of the energy system, causing non-renewable (mineral) resources such as the rare earth elements to be of high significance for the transformation. To analyse social conditions (human well-being) throughout the life cycle of the product we focused on five major functionings (welfare basis, health & safety, social participation, democracy & freedom, decent life) and assigned 24 impact issues to them to enable an assessment of the social effects of the rare earth production along the whole process chain.
The analysis of social impacts of the production of the rare earth elements using S-LCA is developed to illustrate the connection between the S-LCA and the capability approach – Amartya Sen's concept of human well-being.

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Keywords: Energiewende, Non-Renewable Resources, S-LCA, Capability approach

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1. Introduction

Since the nineteen seventies, science and society have been discussing the worldwide ecological, economic and social problems caused by industrialization, globalization and the energy system. Sustainable development is perceived as a strategy for coping with these problems. The global demand for sustainable development leads to a question posed by Amartya Sen: Who and what has to be sustained [1]? And then answered by him: "It is not so much that humanity is trying to sustain the natural world but rather that humanity is trying to sustain itself [2]." That is to say, our consumption and production patterns have to be altered. In Germany the transformation of the energy sector (Energiewende) is at the centre of that process [3-5] and renewable energy technologies are seen as instruments for this transformation [6]. In order to realize its 450ppm scenario [5], the IEA assumes "investment in renewables of $6.4 trillion is required over the period 2012-2035 [5]." Renewables, such as solar cells, or wind turbines, are techniques for sustainable energy development. However, these renewable energy technologies need non-renewable mineral resources and especially rare earth minerals [6, 7]. Rare earth elements (REEs) are used in nearly every renewable energy technology, in solar panels, fuel cells, batteries, wind power magnets, energy, saving lighting and automotive catalysts [8, 9]. The American Physical Society (APS) confirms the great need for REEs in the transformation of the energy system [10].

The Rio +20 conference in 2012 confirmed not only the sustainability concept as the new development goal but also introduced the green economy as its implementation strategy and the life cycle assessment as one of its analysis tools to reveal the current production and consumption patterns which affect human well-being [11-14].

In 2009, UNEP and SETAC published guidelines for social LCAs to enable a social assessment of products in their supply chain [15] in addition to an environmental assessment because life cycle thinking "offers a way of incorporating sustainable development in decision-making processes [11]." The aim is to analyse and improve social conditions (human well-being) throughout the life cycle of the product [15]. Therefore human well-being has to be defined. We describe human well-being using the capability approach of Amartya Sen [14] as suggested by UNEP/SETAC [15].

2. Methodology

2.1. Human well-being – the capability approach

Amartya Sen and Martha Nussbaum try to capture people's well-being under current production and consumption patterns with their capability approach by considering not only people's income but also non-monetary aspects which influence people's welfare and their quality of life [16].

The capabilities (realization chances) describe a person's opportunities of using his functionings (abilities) to achieve his place in society. Capabilities are therefore a vector of individual abilities (functionings), which can be developed by individuals themselves as a function of basic social conditions (democracy, freedom) [14, 16].

In the same way that a person who has a lot of money can purchase many goods, a person with many functionings can choose between different life concepts [17]. These functionings enable people to earn income and to purchase the goods they need. The functionings therefore refer to the possibility of fulfilling individual needs (being healthy, well-nourished, safe, having a good job). The capability budget (amount of functionings) defines people's welfare and "the person's freedom to live one type of life or another [18]." The budget for our analysis contains based on Sen and the Human development index [14, 19] the following central functionings: welfare basis, decent life, nutrition, mobility, social participation, education, and health. The aim is to make the functionings of the capability budget in a S-LCA comparable and measurable.

However, production and consumption patterns have an influence on human well-being, people's functionings and capabilities. The current unsustainable patterns [20] have to be altered and in Germany the energy sector is at the centre of that process.

2.2. Social impact assessment

There are no internationally approved methods for implementing a social life cycle assessment like those for a classical ecological LCA (ISO 14040/44) [22]. We use the UNEP/SETAC Guidelines [15] and an openLCA based model developed by GreenDelta [21] as a basis for our social LCA (S-LCA) analysis.

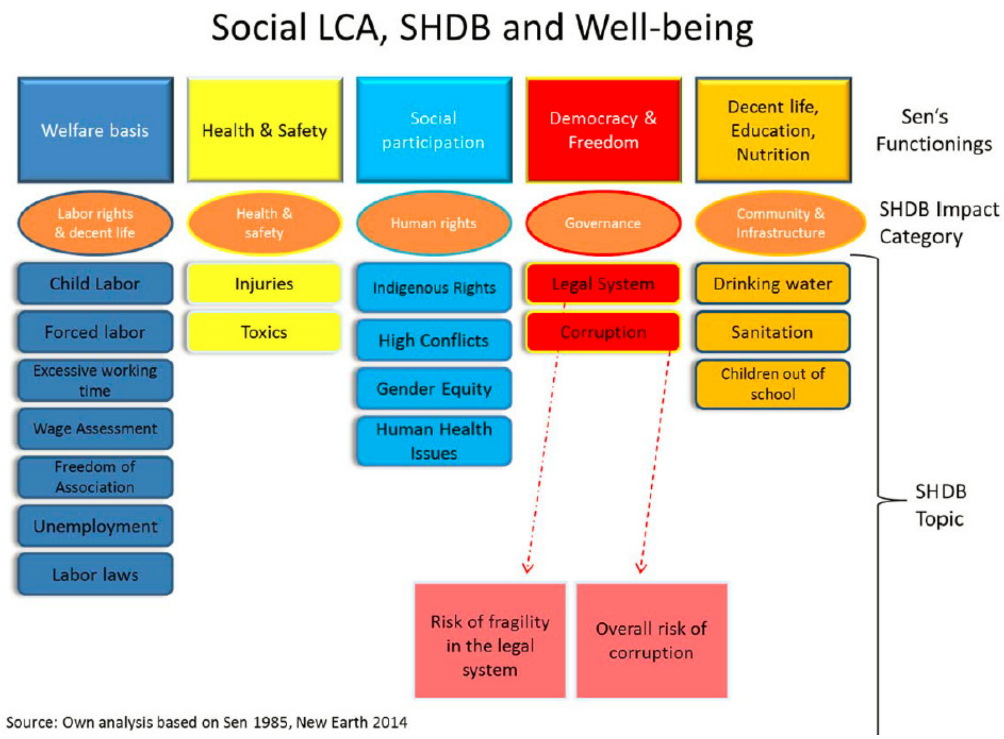
In the same way as for ecological LCA, big data sets are also needed for social life cycle assessments (S-LCAs). There are only a few suitable databases for social LCAs. We use the Social Hotspots Database (SHDB) of New Earth, which assigns social risk points to every single production step [22-24]. The database originated from the work on the UNEP/SETAC Social LCA Guidelines and was developed by the NGO New Earth [23, 24]. The SHDB contains detailed social information along the life cycle chain in 113 countries and enables us to examine the social conditions in these countries.* The advantage of the SHDB is, that "it includes a Global Input Output (IO) model derived from the Global Trade Analysis Project, a Worker Hours Model constructed using annual wage payments and wage rates by country and sector, and Social Theme Tables covering 22 themes within five Social Impact Categories—Labour Rights and Decent Work, Health and Safety, Human Rights, Governance and Community Impacts [23]."

2.3. Assessing S-LCA to describe the capability approach

By relating the S-LCA to the capability approach of Sen in order to capture the social conditions of production and consumption patterns, the functionings of the capability budget are made comparable and measurable in an S-LCA. This approach enables us to analyse who and what has to be sustained.

For this analysis, we use the suggested five major impact categories (labour rights & decent work, health & safety, human rights, governance, community & infrastructure) [23, 24] and assigned to them 24 impact issues (Figure 1).

Figure 1:



On the example of child labour our methodology can be explained, because it clarifies our new methodology and illustrates the connection between the S-LCA and the capability approach. Child labour is an important social aspect because it "not only undermines the roots of human nature and rights but also threatens future social and economic progress worldwide"† as the UN stated. Child labour prevents children from developing functionings which would enable them to live the life they want to and child labour restricts their future capabilities because of their lack of education and the health effects of child labour. The capability budget (amount of functionings) is forcibly reduced and the future welfare of the children is limited. The children cannot choose between different life options. Production and

* GreenDelta, Social Hot Spots Database in openLCA, Quick explanation

† http://www.un.org/en/globalissues/briefingpapers/childlabour/index.shtml

consumption patterns tolerating child labour dramatically reduce the child's future choices. They reduce their quality of life and their capabilities [25].

3. III The example of rare earths

Rare earth elements are used in many renewable energy technologies and they will serve as an example to test the approach. Today rare earth elements are mainly produced in China (>95%).In addition, there are also some production facilities in the USA and in Australia and Malaysia, although the amounts involved are small. The aim will be to compare these different production lines from a social perspective. The results will vary because of the different ore types, ore compositions and technologies used, but also because of the different social conditions. To describe the different process chains the production of rare earths is divided into 4 segments:

1. Mining
2. Processing
3. Separation
4. Electrolysis

In a first step, the physical interrelations (e.g. materials, energy demand, emissions, waste) are modelled to describe the different life cycles. Next, the inputs are related to sectors used in the SHDB. The sectors considered are shown in table 1.

Table 1: Sectors of the SHDB Analysis

Mining	Processing	Separation	Electrolysis
Oil	Oil	Oil	Electricity
Gas	Gas	Gas	Chemical, rubber, plastic products
Electricity	Electricity	Electricity	Metals
Water	Water	Water	Transport
Chemical, rubber, plastic products	Chemical, rubber, plastic products	Chemical, rubber, plastic products	
Transport	Ferrous metals	Minerals	
Construction	Minerals	Transport	
Machinery and equipment	Transport		
Water transport	Machinery and equipment		
	Construction		

Source: Own calculation IEK-STE 2014

To combine the physical values of a process chain with the ecologically based sector functions of the SHDB, in a third step regional specific prices have to be assigned to the sector products. The S-LCA model calculates risk points for each impact issue. The risk points will be assessed for each process chain. The life cycle approach allows a comparison of the three process chains but also provides information about social hot spots within each process chain. Also the regional occurrence of the social effects can be made visible. While most impact issues will occur at the production locations others will arise in different countries due to imports.

4. Conclusion

Using the example of rare earth production in three regions, a new method based on a social LCA and the capability approach (Amartya Sen's concept of human well-being) is implemented. The analysis of social conditions (human well-being) throughout the life cycle of rare earth production focuses on five major functionings (welfare basis, health & safety, social participation, democracy & freedom, decent life). The approach allows the comparison of the different process chains and makes regional variations of social effects visible.

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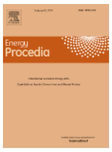

Biography

Holger Schlör studied economics at the University of Heidelberg and went on to complete his PhD in Economics in Berlin. He received a scholarship from the German Marshall Fund and the Alfried Krupp von Bohlen und Halbach-Foundation. He has conducted research at several scientific institutions and the German Parliament. He is currently working at Forschungszentrum Jülich in the Institute of Energy and Climate Research – Systems Analysis and Technology Evaluation (IEK-STE). His research here focuses on the fields of sustainable development, economics and energy systems analysis. He is member of International Centre for Sustainable Development of Energy, Water and Environment Systems - SDEWES Centre.